

MAKING COLOR PRINTS

**By
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CHAPTER VIII
IMBIBITION PRINTING
Wash-Off Relief Process

IN the process to be described, a film coated with a silver emulsion is exposed to light under a negative, developed but not fixed, then bleached in a bichromate-sodium chloride solution. The emulsion is hardened where the image appeared while the unaffected parts can be washed out in warm water, and a relief image remains. The films have to be exposed through their base, otherwise the image will not have a support and will wash off in the water. This image will absorb dyes proportional to the degree of swelling in various parts of the reliefs. Placing the stained images in contact with a swollen gelatin paper will release the dyes to this paper, which is treated with salts to give it an affinity for dyes greater than the relief film (Fig. 9).

This method, first commercially introduced by Eastman Kodak Company, is known as the Wash-Off Relief process. The procedure is fairly simple, requiring no special equipment other than the special relief film, dyes, and specially treated backing paper. Many duplicates can be made simply by returning the reliefs to the dye baths for restaining after transfer to the paper. Numerous controls can be exercised at various stages, therefore the process is very popular among amateur and professional photographers alike. The process is independent of temperature and humidity.

Making the Positives

As the relief films are not fixed after being developed, we have to use another photographic emulsion for test

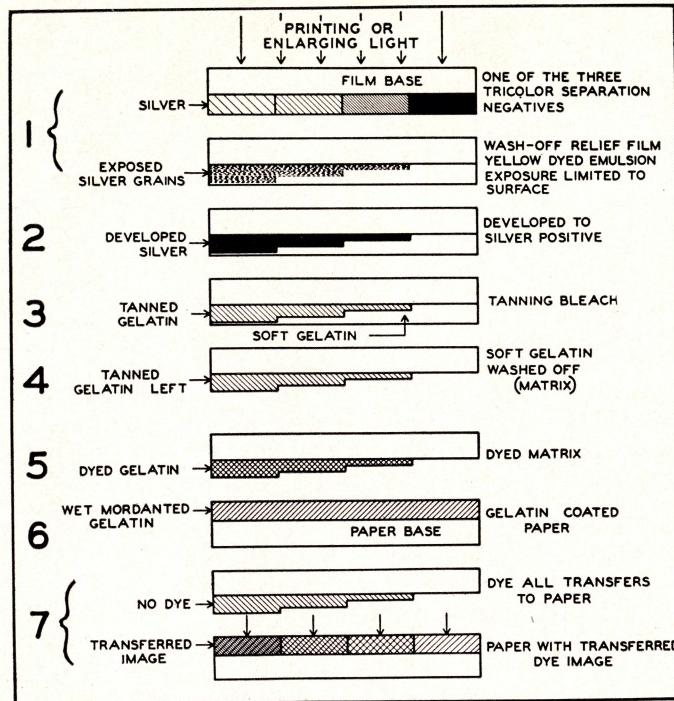


Fig. 9. Steps in the Wash-Off Relief process. Matrices transfer dye to final paper similar to action of plates in color printing.

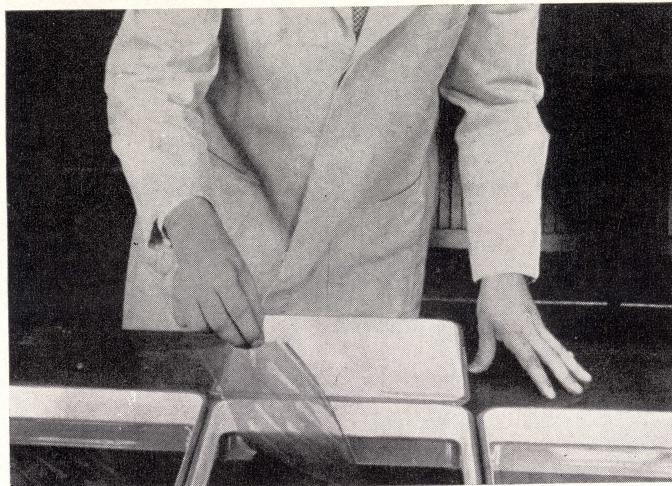
prints, with characteristics similar to the relief film. Best comparisons are made on Kodabromide F No. 3 paper which is processed in Eastman developer D-72, diluted 1 part developer to two parts of water, for exactly $1\frac{1}{2}$ minutes at 70° F . After following the routine of obtaining exposure values for the separation negatives, we apply these times without change when exposing the relief films.

Handling the relief films under an Eastman OA safe-light, they are printed either by projection or contact.

The films are dyed yellow and are very thin; lay them on black paper when you place them on the easel, emulsion side down. Expose the three films in succession, then develop in Eastman formula DK-50 for five minutes at 70° F. You can either develop the three films together, using plenty of developer in the tray and keeping them from sticking together, or in separate trays. Wash the films for at least 10 minutes in running water. In the meantime the bleaching solution, which can be mixed before beginning the procedure, is poured into a tray. The temperature of the solution should be kept at about 68° F. Bleaching of the films is accomplished in 4 minutes. Again you can bleach the films together or in separate trays, but be sure that the films are agitated constantly, otherwise streaks are caused by uneven bleaching. Streaks are not removed by prolonged immersion in the bath as the solution exhausts easily.

Now under white light each relief is developed individually in hot water (120° F.) by immersing each film separately in the tray and rocking it. After a minute or so, the unexposed gelatin begins to dissolve. Remove the film by holding it with one corner, discard the dirty water, and refill the tray with clean water of the same temperature. Replace the film in the tray and continue to agitate until no more soluble emulsion will come off. Several changes of water are necessary. Chill the film in cold water, then clear the whitish image in a fixing bath. After development in hot water, the images are very delicate; be careful not to touch them. Clearing in the fixing bath takes but 1 minute, followed by washing for about 5 minutes, and drying. After all three images have been thus treated they are ready for the toning.

Pour each of the dye solutions into individual trays, slide the proper relief images into them, and by agitation allow the films to absorb the dye. The time required is 20 to 30 minutes. After dyeing, each film is rinsed in several changes of dilute acetic acid. Begin with the magenta. Lift the dyed film out of the tray, let the surplus dye drain off into the tray, and then place it in a tray



After positives made from the separation negatives have been developed and bleached, the three resulting matrices are dyed.

filled with 1/10% acetic acid. Shake the film until no more dye seems to loosen, discard the colored bath, and rinse the film once more in clean dilute acetic acid of the same strength. Then place the film in a 1/2% acetic acid solution. Repeat the procedure with the blue-green and yellow, except that the latter is rinsed in 1/2% acetic acid as the yellow dye washes off easily.

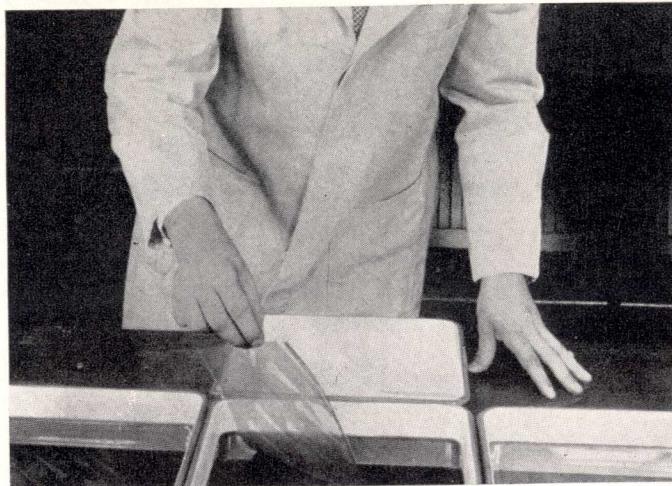
Assemble the films, magenta on the bottom, blue-green in the middle, and the yellow on top, upon the bottom of a white tray for inspection. Any corrective treatment can be determined easily. If the combined images seem to give a satisfactory color rendition they can be transferred immediately.

Any fixed-out photographic paper can be used for the final support, but it has to be treated in a so-called "mordanting" solution in order that it will absorb the dyes. The paper is first soaked for five minutes in an aluminum sulfate solution; it is washed for five minutes

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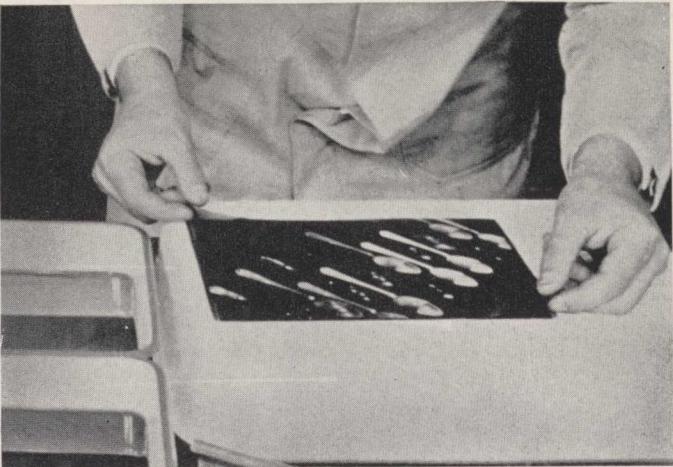


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The three dyed matrices are placed in register on the bottom of a white tray to determine whether any correction is necessary.



The magenta-dyed matrix is the first to be placed on the mor-danted paper, where it remains until the image is transferred.



The blue-dyed matrix is placed in register with the magenta image, using protective celluloid sheet during registration.



After the yellow-dyed matrix has been registered and printed, it is removed, revealing the finished Wash-Off Relief print.

and then covered with a 5% solution of sodium acetate for five minutes. It is then washed again for five minutes. This paper can be used immediately or at a later date. If you contemplate making many prints it is well to mordant several sheets at one time. They keep for a long time.

First the magenta is transferred. The well-soaked support paper is squeegeed upon a glass, stretched to all sides, then transferred to a damp blotter to prevent its drying out. Rinse the magenta relief film in 1/10% acetic acid and place it face down on the paper. Holding the film on one side, first run the squeegee lightly over the surface, repeating and increasing the pressure with each stroke. Finally the full pressure of your arm bears down on the final strokes. Cover the relief with a blotter (dampened with hot water) upon which is placed a heavy plate glass or similar weight. The time of transfer is from 10 to 30 minutes, requiring more time when there is a heavy image. After the transfer is completed, peel the relief film from the paper; the film should only show a trace of color.

Now transfer the blue-green. As these dyes begin to transfer immediately, first place a wetted thin celluloid sheet on the magenta image so that it will cover all but one safety margin. The wet blue-green relief film is laid on this celluloid and moved around until the two images appear as one. Pressing firmly the safety margin of the blue-green into contact with the uncovered safety margin of the paper, lift the relief film and, while holding it between your teeth, remove the thin celluloid with your right hand. Release the relief film which will now fall back on the magenta image in register. Repeating the squeegeeing procedure as before, lock the film in register. Again cover with the hot, wet blotter and the glass plate. The transfer time is about the same as for the magenta. Then repeat this procedure of registration with the yellow after rinsing in $\frac{1}{2}\%$ acetic acid.

The final print can either be dried between blotters or squeegeed to a ferotype tin. Spotting can be done on the individual transfers or on the combined picture, using the dyes in concentrated form and mixed with acetic acid.

Controls

As we mentioned before, the transfer of the dye is governed by the amount of acetic acid added to the dye solutions. If no acid were used we would get a weak and flat print. At the end of this chapter we list the amount of acetic acid to be added as recommended by the different dye manufacturers. Now, an increase of this normal amount produces a more contrasty print, and a decrease will result in a flatter transfer.

When you make your first inspection and decide that your print lacks brilliance, separate the relief films and place them in dye solutions containing more acetic acid. Agitate the films for about half the time used in normal procedure, then follow the steps as usual. However, should the picture appear to be too vivid, remove the dyes completely by washing them in tap water. After a rinse in distilled water, immerse the colorless matrices in a dye solution containing less acetic acid than before; staining time with agitation will be the same as for normal use. In this way you can make all three or any one of the transfers suitable for the best-looking picture.

We can also exercise a certain amount of control over the overall density of the print or part of it. If all three or only one of the reliefs seems to be too dark, soak the film in a tray filled with water; after a few minutes the image begins to "bleed." Remove the film and stop further loss of color by placing it in diluted acetic acid. If all three are to be reduced in density, let them soak in the water for exactly the same time. If only part of the picture needs to be brightened, place the film on a tray held at an angle and apply water with the hose (at very low pressure). Only experience will teach you when to stop, so it is better to reduce too little than too much.

If, on inspection, the print seems to be much too light, you may make two transfers from each relief film. Just restain the matrix after the first transfer and repeat. Of course registration will not be too easy.

Condensed Instructions For Wash-Off Relief

[Eastman System]

Step

1. Make test exposure on Kodabromide F No. 3 from green-filter negative. Develop.
2. Choose appropriate exposure and make full-size print.
3. Compare gray scales of blue-green and yellow printers and determine exposure adjustment.
4. Make exposure on Wash-Off film. Expose through back of film. Put relief film on black paper. Develop for 5 min. View and develop films emulsion side down.
5. Wash for 10 minutes in water not over 70° F. Edgemark films for each color.
6. Bleach films for 4 minutes in Eastman bleach at about 68° F.
7. Develop each film individually in water 120° F.
8. Fix reliefs in F-1 for 1 min.
9. Wash films for 5 minutes.
10. Dry films (now called matrix).
11. Dye reliefs in A, B, C dyes for 20 minutes. Agitate frequently.
12. During dyeing, prepare final support paper; bathe in mordant No. 1 for 5 min., wash 5 min., bathe in mordant No. 2 for 5 min., wash 5 min.
13. Rinse magenta and blue-green reliefs in 2 changes of 1/10% acetic acid (yellow in 2 changes of 1/2% acetic acid). Agitate constantly, place in tray containing 1/2% acetic acid until ready for transfer.
14. Inspect reliefs for color balance.
15. Squeegee well-soaked support paper on flat surface, then transfer to damp blotter.
16. Rinse magenta relief in 1/10% acetic acid and squeegee to paper.
17. Cover with warm wet blotter and warm glass plate for about 20 minutes.
18. To transfer blue-green, remove magenta, cover paper with Kodaloid which has been wetted in 1/10% acetic acid leaving paper margin. Rinse blue-green in 1/10% acetic acid and place on Kodaloid for register. Remove Kodaloid, squeegee film in place. Cover with warm wet blotter and glass.

Materials

- Tray of D-72, 1:2 at 70° F.
Tray of short-stop.
Tray of fixer F 1.
Kodabromide F No. 3

Tray of DK-50 developer.
Wash-Off film.
Black paper.

Bleaching solution: one part A, 1 part B, 6 parts water.
Hot water at 120° F.

F-1 fixing bath.

Eastman A, B, and C dyes.

Mordant No. 1 and No. 2 solutions.
Eastman Imbillion paper.

1/10% acetic acid solution.
1/2% acetic acid solution.

Squeegee and damp blotter.

1/10% acetic acid solution;
squeegee.
Warm wet blotter; glass plate.

Kodaloid
Same as in 15, 16, 17.

19. Repeat with yellow, using 1/2% acetic acid rinse.

20. Dry between blotters or on ferro-type tin. Dry blotters or ferrotype tin.

21. Spot dry print if necessary with the dyes wetted with strong solution of acetic acid, apply with spotting brush.

Curtis Orthotone Process

Largely following the standard procedure as developed by Eastman, the Orthotone process modifies some steps through the use of special dyes, developers, and control solutions. The use of Orthotone developers permits a certain amount of contrast control when processing the exposed matrices. When the relief films are processed in Orthotone formula No. 107 in conjunction with Orthotone Control Solution, or in concentrated Orthotone Developer, there is a definite relationship of their exposures with test prints made on Kodabromide No. 2 paper, the latter being developed in D-72 for 1½ minutes at 70° F. When using formula No. 107, increase the exposure of the matrices 25% over that of the test prints; with the Orthotone Developer, increase the exposure 1½ times. While the Orthotone Developer is used for all-around work and, with the addition of potassium bromide, gives more contrasty results, the special formula No. 107 used in conjunction with the Control Solution affords a variety of adjustments most suitable when working with negatives of different contrasts. A control guide is given with the formula farther on in this chapter.

Orthotone dyes are sold in concentrated solutions and therefore can be easily prepared for use. Staining time is much less than required with the Eastman dyes, requiring only 5 to 10 minutes. The transfer time required is also about 5 to 10 minutes. In all other respects this process follows the usual procedure.

Condax-Speck System

Again following the standard procedure, this system differs mainly in the use of Dytrol dyes, made by Condax-Speck, Inc. After the matrices have been stained for 5 minutes, they are rinsed for 5 minutes in a 1% solution of acetic acid with constant agitation. Be sure to use the same amount of rinse and the same rinsing time for all three films. After a final rinse in $\frac{1}{2}\%$ acetic acid, the films are ready for inspection. Corrections are made in the usual manner, and about 4 to 7 minutes time is required for each transfer.

The Chromax-Dyeset process, produced by Tricol Color Products, follows the Condax-Speck system very closely, except that the use of Eastman DK-20 developer is recommended instead of the conventional DK-50.

When Defender Chroma Relief film is used in imbibition printing, the matrices are developed in Defender 6-D developer. Test strips are made on Defender Velour Black No. 22, which is also developed in 6-D. Exposures found for test strips should be decreased about 50% when exposing the films. Developing time can be varied from 3 to 5 minutes in order to control contrast.

A special system for making wash-off relief prints, described by Ted McIntire (Photo Technique, May, 1940), employs a tanning developer, eliminating the hardening bleach bath and washing between developer and bleach. An oxidized pyro developer causes the reliefs to be selectively hardened, and this process speeds up the making of a print considerably. The solutions which are needed are as follows:

Solution A		
Sodium sulfite	50 grains	
Pyro	$\frac{1}{2}$ ounce	
Potassium bromide	50 grains	
Water to make.....	16 ounces	
Solution B		
Sodium carbonate	2 ounces	
Water to make.....	16 ounces	
Solution C		
Sodium bisulfite	3 ounces	
Water to make.....	30 ounces	
Solution D		
Potassium ferricyanide	3 ounces	
Water to make.....	30 ounces	

After exposing the three relief films, develop them for 3 minutes at 70° F. in a solution made up of equal parts of Solutions A and B. After development the solution is exhausted and should be discarded. Now cover the films with Solution C, and after a few seconds discard this solution and fill the tray with water at 110° F. Change water until all the soluble gelatin is washed out. Discard the water, and bathe films in a small amount of regular fixing bath. Rock the tray for a minute or two, then discard solution, cover the films with Solution D, and agitate constantly until the films turn a muddy brown. Wash the films for 5 minutes, and without drying them place each in its dye bath for 5 to 10 minutes. After dyeing, the magenta and blue-green matrices are rinsed in a 2% solution of acetic acid, the yellow is rinsed in plain water, and all are hung up to dry. From here on the regular procedure is followed.

Notes on Relief Film

Most workers devise their own method of registering the relief films if they find it inconvenient to work with the celluloid as described. Condax-Speck supply a special board with two raised and adjustable pegs over which punched film can be placed in proper position, one after the other. Dr. Curtis, in his color handbook, mentions a method of registration using large paper clamps. As the relief films are very delicate, some photographers use wooden clips to handle them. The emulsion can be toughened by placing the films in a formalin hardening bath—50.0 cc formaldehyde (40%) in 1000.0 cc of water—where they are allowed to soak for 4 minutes before they are hung up to dry. Some manufacturers recommend that the brownish residual image be removed after the matrices are fixed. This can be done with Eastman R-2 permanganate reducer. Opinion regarding the advisability of this treatment is divided. Eastman lists it as optional. An advantage, however, is the absence of the stain while inspecting the dyed images prior to the transfer.

Materials for Imbibition Printing

Materials for making wash-off relief prints can be obtained from several manufacturers. You can select them from the following list:

Relief Films

Eastman Wash-Off Relief Film.
Defender Chroma Relief Film.

Dyes

Eastman Wash-Off Relief Dyes—A, B, and C.
Orthotone Tricolor Dyes, concentrated.
Dyetro Tricolor Dyes.
Chromax-Dyeset Dyes.

Comparison Papers for Test Exposures

Eastman Kodabromide No. 3 (for Eastman system).
Eastman Kodabromide No. 2 (for Curtis system).
Defender Velour Black No. 22 (for tests when Chroma Relief film is used).

Final Support Papers

Defender BT Backing Paper.
Defender Backing Paper, Pre-mordanted.
Eastman Backing Paper for Final Transfer.
Condax-Speck Backing Paper, Pre-mordanted.
Chromax-Dyeset Paper, Pre-mordanted.

Formulas

Paper Developers

Eastman Developer D-72

For use only in comparison tests on Kodabromide paper
Stock Solution

Water (125° F.)	500.0 cc	
Elon	3.1 grams	
Sodium sulfite, desiccated	45.0 grams	
Hydroquinone	12.0 grams	
Sodium carbonate, desiccated	67.5 grams	
Potassium bromide	1.9 grams	
Water to make	1.0 liter	

Use 1 part stock solution to 2 parts of water; develop for 1½ minutes at 70° F. Use Kodabromide No. 3 when using Eastman Dyes.

Defender Developer 6-D

For use in comparison tests made on Velour Black No. 22 when Chroma Relief film is used. Film is also developed in 6-D.

Water (120° F.)	3.0 liters
Metol	7.8 grams
Sodium sulfite, desiccated	390.0 grams
Hydroquinone	20.0 grams
Borax (crystals)	7.8 grams
Water to make	4.0 liters

Use without dilution at 70° F. After determining exposure on Velour Black No. 22, decrease exposure on Chroma Relief film 50%. Develop 3 to 5 minutes according to contrast desired. Use 1% acetic acid short-stop bath.

Matrix Developers

Eastman Developer DK-50

For Eastman and Condax-Speck systems

Water (125° F.)	2.0 liters
Elon	10.0 grams
Sodium sulfite, desiccated	120.0 grams
Hydroquinone	10.0 grams
Kodalk	40.0 grams
Potassium bromide	2.0 grams
Water to make	4.0 liters

Develop for 5 minutes at 70° F.

Eastman Developer DK-20

For Chromax system

Water (125° F.)	2.0 liters
Elon	20.0 grams
Sodium sulfite, desiccated	400.0 grams
Kodalk	8.0 grams
Potassium thiocyanate	4.0 grams
Potassium bromide	2.0 grams
Water to make	4.0 liters

Develop for 8 to 12 minutes at 65° F.

Orthotone Concentrated Developer

Dilute 1 part of the developer with 31 parts of water. Develop for 5 minutes at 70° F. To increase contrast add 10% solution of potassium bromide and increase exposure. Increase the exposure 3 times over test on Kodabromide No. 2 when bromide is used, and 1½ times when it is omitted.

Orthotone Developer No. 107

Water (125° F.)	2.0 liters
Elon	6.0 grams
Sodium sulfite, desiccated	260.0 grams
Hydroquinone	32.0 grams
Sodium carbonate	60.0 grams
Potassium bromide	8.0 grams
Water to make	4.0 liters

Develop for 5 minutes at 70° F. Increase exposure of matrices 25% over that of test prints on Kodabromide No. 2. As this developer gives

brilliant results, the addition of Orthotone Control solution is recommended. Here is an approximate guide to Orthotone control:

Per cent Control Sol.	Exposure Decrease	Suitable Negative	Print Result
O	O	Soft	Brilliant
½%	30%	Normal	Brilliant
1%	50%	Med. Contrast	Normal
2%	60%	Med. Contrast	Soft
3%	60-70%	Hard	Soft

1% Short-Stop Bath

Acetic acid (99%).....	10.0 cc
Water to make.....	1.0 liter

Eastman Acid Hardening Fixing Bath F-1

Water (125° F.).....	2.0 liters
Hypo	480.0 grams
Then add the following hardener slowly to the cool hypo solution while stirring the latter rapidly.	
Water (125° F.).....	160.0 cc
Sodium sulfite, desiccated.....	30.0 grams
Acetic acid (28%).....	96.0 cc
Potassium alum.....	30.0 grams

Clear relief films for 1 minute at 70° F. or use:

Non-Hardening Fixing Bath

Water (125° F.).....	500.0 cc
Hypo	240.0 grams
Sodium sulfite, desiccated.....	10.0 grams
Sodium bisulfite.....	25.0 grams

Water to make..... 1.0 liter

Clear relief films for 1 minute at 70° F.

Matrix Bleach—Eastman R-10a

For all systems

Solution A	
Water	500.0 cc
Ammonium bichromate	20.0 grams
Sulfuric acid (C.P.)	4.0 cc
Water to make.....	1.0 liter
Solution B	
Sodium chloride	45.0 grams
Water to make.....	1.0 liter

Use distilled water to mix these solutions. For use, take 1 part A and 1 part B, and add 6 parts water. Bleach for 5 minutes at 70° F. Agitate the films constantly, each for the same length of time. If films are bleached one after another, use a fresh bath each time as the solution exhausts quickly.

Mordanting Solution—Eastman M-1

Solution A	
Aluminum sulfate	200.0 grams
Water to make.....	1.0 liter

Solution B

Sodium carbonate, desiccated.....	40.0 grams
Water to make.....	500.0 cc

Add Solution B to Solution A, stirring constantly until clear. Filter. Soak the special backing paper for 5 minutes, followed by a 5-minute wash. Then soak for another 5 minutes in the following solution:

Sodium acetate	50.0 grams
Water to make.....	1.0 liter

Preparing Dye Solutions

Use sufficient boiling water (distilled) to dissolve dyes, then add cold distilled water to make up the volume, and filter before pouring into the storage bottles. Eastman powdered dyes are made up as follows: 30.0 grams of powder dissolved in 5.0 liters of water. Add 5.0 cc of formalin to each 500.0 cc of dye solution. For normal dye transfer add 10.0 cc of 5% acetic acid to each 500.0 cc of cyan (blue-green) and magenta dye, and 15.0 cc of 5% acetic acid to each 500.0 cc of yellow dye. A 50% increase or decrease of these amounts will give harder or softer transfers; for more critical control use intermediate amounts.

Orthotone concentrated dye solutions are diluted with distilled water, 20.0 cc of dye solution diluted to 600.0 cc. As a preservative add 5.0 cc of formalin to each 500.0 cc of the diluted solutions.

With Condax-Speck Dyetrol dyes, prepare according to the procedure with Eastman dyes, but do not add any preservative, as it is already contained in the powdered dyes. Add 50 minimis of 28% acetic acid to each quart of dye solution for normal transfers.

Eastman Reducer—R-2

To remove residual silver image left in the matrices after bleaching and fixing (optional).

Solution A	
Potassium permanganate	52.5 grams
Water to make.....	1.0 liter
Solution B	
Water	1.0 liter

Solution B	
Sulfuric acid (C.P.)	32.0 cc
NOTE: Add sulfuric acid slowly to cold water, stirring constantly.	

For use, take 1 part A, 2 parts B, and 64 parts water. After reduction, rinse films for 3 minutes, immerse in any fixing bath for 1 minute, then wash again for 5 minutes. Hang films up to dry.

Chromax Formula

For reducing silver image

Solution A	
Potassium permanganate	2 ounces
Water to make.....	16 ounces
Solution B	
Sodium bisulfite	1 ounce

Dilute 1 part Solution A with 15 parts water. Immerse matrix for 1 minute, rinse 1 minute, then place it in Solution B (undiluted). Leave it in the second solution for 1 minute or until clear, then wash for 2 minutes and dry.

CHAPTER IX

TRICOLOR BROMOIL PRINTING

THIS is a dyed gelatin method similar to Wash-Off Relief. Prints are made on film and treated in different salts until a relief image is obtained. These relief films are wetted and then inked. Due to the incompatability of greasy ink and water, the films absorb ink only where there is no water. These inked-up surfaces are then pressed to paper, and in such manner an image is transferred. The drawback to this process is a very vital one. The gelatin reliefs are rather soft and therefore will not produce as sharp an image as we obtain with the other subtractive printing processes.

The three positives are made on Agfa Process Films from the respective separation negatives. They are developed in a metol-hydroquinone developer. This solution should be fresh, otherwise a partial tanning of the gelatin might result. The films are fixed in a non-hardening fixing bath and then washed very thoroughly. Bleaching can follow immediately. While there are many formulas published in books on bromoil printing, we suggest trying one contained in a book by Dr. Emil Mayer, *Bromoil and Bromoil Transfer*. The formula is given below. These solutions bleach and tan the image simultaneously.

A. Copper sulfate	200.0 grams
Water to	1.0 liter
B. Potassium bromide	200.0 grams
Water to	1.0 liter
C. Potassium bichromate	10.0 grams
Water to	1.0 liter
For use take:	
A	60.0 cc
B	60.0 cc
C	20.0 cc
Water to	450.0 cc
Hydrochloric acid (conc.)	15 drops

The temperature of these baths should be uniform between 55° and 65° F.

The films are washed thoroughly and then fixed for two minutes in a 10% solution of hypo. Be sure that washing is thorough before immersing the print in the hypo. An acid hardening bath cannot be used. Again the films are washed for about 10 minutes and then dried. When the film is bleached, the procedure can continue under white light.

Now we are ready to ink these relief films. First immerse the red film in water for about five minutes. The water should be kept at a temperature between 75° and 80° F. Prepare a small amount of the red ink on a piece of glass and distribute it as far as possible all over the glass with a pallet knife. A special roller has to be used, which should be moved over the ink several times until the roller takes up the ink very evenly. Place the relief film on a moistened blotter. Blot off the surface with a piece of chamois and remove the relief film to a piece of glass. Now take your roller, set it on one side of the relief film, press down firmly, and roll slowly over to the other side. Re-ink the roller, start from the other side and again with even pressure move the roller across. It is difficult to say how much pressure you should apply. Only experience will tell you if the pressure you use is sufficient or not.

Next, lay the film face down on a paper. Place the sandwich between two blotters and roll it through a wringer. Then remove the film and repeat the inking procedure with your next color. First put down the red ink, then the yellow, and on top of it the blue. When you have inked the yellow image, the following procedure should be used to place it in registration on top of the red image on paper. Hold down the film on two corners and very lightly lower the film over the red image. As you can look through the film, move it until the two images coincide. Then with a roller and light pressure lock the two images. Again place the two between blotters and roll them through the wringer. Repeat the inking and registering methods with the blue image, or follow the registration method as outlined in Chapter VIII.

We now have a print in natural color. The inks manufactured for this purpose are sometimes not satisfactory enough to give a good, rich print with three colors. Therefore, you can employ a fourth color—black—to give the print depth and brilliance. If you have a set of three separation negatives, you can make a very thin print from the red-filter negative on the process film. Process it as the others, but ink it up with a special black ink. Do not touch the surface of the final print until it is perfectly dry. This will take some time, depending upon the humidity and temperature of your surroundings.

The materials and special tools, including inks and chemicals, can be bought from the Chemical Supply Company, Hollywood, Calif., under the name of Champlin-color Kit. Additional material needed is the Agfa Process film. Another brand of ink can be bought from Charles H. Parkington, 2780 Highland Ave., Norwood, Cincinnati, Ohio. A set of tricolor red, blue and yellow costs \$2.10, and with the addition of warm black, \$3.15.

CHAPTER X

TRICOLOR PRINTING WITH DYE-COUPLED COLOR DEVELOPERS

RECENTLY there have appeared in magazines several articles on tricolor printing with dye-coupled color developers, a more or less unfamiliar method of making tricolor prints. We have tried it with moderate success. The basic principle of dye-coupling is in a way simple. Black-and-white prints are developed in a solution similar to the usual formulas but containing chemicals which, during the development, convert the metallic silver image into a salt which can be replaced automatically by an insoluble organic dye. This reaction is produced through the oxidation products obtained between a developing agent and certain substances in the developer or emulsion.

For tricolor printing, use a stripping film like Chromatone printing paper. After making the various tests to establish the exposure ratio, develop the three positives separately in the following solutions:

Basic Developer

Stock Solution:	
Sodium sulfite	18.00 grams
Sodium carbonate	40.0 grams
Potassium bromide	1.0 gram
2-amino-5-diethylaminotoluene monohydrochloride	1.5 grams
Water to make.....	1.0 liter

More or less quantity of the developing agent increases or decreases the strength and contrast of the print respectively. Too much developer will result in the production of general stain.

Color Formers

Magenta coupler	1.0 gram
P-nitrophenylacetone nitrile	100.0 cc
Acetone to make.....	1.0 gram
Cyan or blue-green coupler	1.0 gram
2,4-dichloro-1-naphthol	100.0 cc
Acetone to make.....	1.0 gram
Yellow coupler	1.0 gram
Acetone 2, 5 dichloroanilide	100.0 cc
Acetone to make.....	1.0 gram

In developing the positives, mix one part of the appropriate color former with 10 parts of the basic develop-

ing solution. This combined developer should be used immediately. Develop the prints for at least three minutes, then rinse them in running water for about one minute. Next immerse them for about fifteen minutes in the following fixing bath:

Sodium sulfite	40.0 grams
25% Hypo solution.....	1.0 liter
Formaldehyde	100.0 cc

The resulting images consist of both silver and dye. The silver is removed by bleaching the prints in Farmer's reducer. The colors are brightened by the removal of the silver, but the contrast of the print is lowered. This should be taken into account when preparing the developer. Contrast can also be increased by increasing the developing time, just as in black-and-white printing.

After washing, the three stripfilms are assembled in register as in the Chromatone process. The order of assembly is as follows—first the yellow, then the magenta, and then the blue-green.

Tricolor Bleach-Out Process

This process employs a paper which is covered with three emulsions, each dyed with one of the subtractive colors. These dyes can easily be bleached out by absorption of their complementary colors when exposed to light in contact with a color transparency. In this way a natural color photograph is obtained. Before exposure this paper will naturally look black. To stabilize the dyes after exposure they are fixed in a special fixing solution.

Load the paper and the color transparency in a printing frame under subdued light. A very long exposure is needed even when using a No. 2 Photoflood placed 6 inches from the printing frame. An electric fan is used to eliminate excessive heat. To inspect the progress, one side of the hinged back of the printing frame is opened in subdued light. The safe-edge color determines the correct exposure, and should be light cream; or you can rely on your judgment by looking at the print in subdued light to observe its density.

After proper exposure, sometimes taking more than one hour, the print is put into a special fixing bath. Agitate the print for at least one minute and leave it in the bath for one hour, checking frequently that the print is well covered with solution. Washing afterward in plain water should not take longer than two or three minutes. The print is then surfaced-cleaned with absorbent cotton, then dried between several blotters. The print can be ferrotyped if a glossy surface is desired.

Paper and fixing bath can be purchased from the Vitachrome Film Corporation.

Manufacturers and Distributors of Color Equipment

Color photography and color printing continues to become more and more popular in the amateur field. Likewise, supplies and equipment are being stocked by local photo supply dealers, particularly in the larger cities. For the benefit of readers who are unable to obtain materials through their local dealers, this list of manufacturers and distributors has been included.

Tricolor Pigment Process

Devin-McGraw Colorograph Co., 175 So. Verdugo Ave., Burbank, Calif.

Manufacturers of tricolor cameras, tricolor pigment papers and monochrome carbon papers. Devin Bromide Paper, and all supplies for this process.

National Photocolor Corp., 305 E. 43rd St., New York, N. Y.
Manufacturers of tricolor cameras, tricolor pigment papers, and all supplies for pigment printing.

George Murphy, Inc., 57 E. 9th St., New York, N. Y.
Distributors for Autotype Carbon and Carbro tissues and sundries, and tricolor cameras.

Caron Color Process

Caron Color Company, Detroit, Mich.

Chromatone Process

Defender Photo Supply Company, Inc., Rochester, N. Y.

Neotone and Orthotone

Thomas S. Curtis Laboratories, 2063 East Gage Ave., Huntington Park, Calif.
Also cameras, color printer, etc.

Imbibition Printing

Eastman Kodak Company, Rochester, N. Y.

Supplies for Wash-Off Relief Process

Defender Photo Supply Company, Inc., Rochester, N. Y.

Chroma-Relief Film and Backing Paper.

Thomas S. Curtis Laboratories; see Neotone.

Supplies for Curtis Orthotone Process

Condax-Speck, Inc., 323 East 47th St., New York, N. Y.

Dyetrol dyes and transfer papers

Tricol Color Products, 18 E. 42nd St., New York, N. Y.

Chromax dyes, transfer paper, and all supplies for imbibition printing.

Tricolor Bromoil Printing

Chemical Supply Co., 6324 Santa Monica Blvd., Hollywood, Calif.

Distributors for Champlincolor

Charles H. Parkington, 2780 Highland Ave., Norwood, Cincinnati, Ohio.

Distributor for Signal Bromoil Inks

Dye-Coupled Developers

Eastman Kodak Company, Organic Chemical Division, Rochester, N. Y.

Developing agents and color formers

Tricolor Bleach-out Process

Vitachrome Film Corporation, 1150 Columbus Ave., Boston, Mass.

Vitachrome paper and fixing solution.